

R E M A R K S

Rejection Under 35 USC 112, Second Paragraph

Claim 1 was rejected under 35 USC 112, second paragraph, for the reasons set forth in item nos. 2 and 3 on page 2 of the December 18, 2007 Office Action.

Claim 1 was amended to resolve the inconsistency between lines 5 and 6, which recites "0.4 to 4% by volume of carbides, nitrides and carbonitrides" and lines 3 and 4 from the bottom which recite "said carbides in an amount of 0.4 to 4% by volume."

Withdrawal of the 35 USC 112, second paragraph rejection is therefore respectfully requested.

37 CFR 1.116

With respect of Rule 116, entry of the amendment to claim 1 is respectfully requested, since such amendment is in reply to the aforesaid 35 USC 112, second paragraph rejection which was set forth in the December 18, 2007 Office Action (final rejection).

Applicants' Claims

According to applicants' claims, a steel material is prepared in such a manner that 0.5 to 1.5 wt% carbon and a total amount of 0.2 to 2.0 wt% of one or more alloy elements selected from the group consisting of V, Ti, Zr, Nb, Ta and Hf are added in a casting stage so that 0.4 to 4.0 % by volume of special carbides of said alloy elements having an average particle diameter of 0.2 to 5 μm are dispersed therein.

A rolling element of the present claims is prepared and made of the steel material preliminarily treated in the above-described way in which fine cementites having an average particle diameter of 0.1 to 1.5 μm are further dispersed by spheroidizing, and a heat treatment is performed so that 2.5 to 10 wt% Cr is solid-dissolved (concentrated) in said cementites. A rolling contact surface of the rolling element is rapidly heated in a temperature region of 900°C or higher by induction hardening so that a part of the cementites is solid-dissolved in austenite, and quenching is performed thereafter. High-toughness martensite containing 0.3 to 0.8 wt% C therein is thus formed.

Regarding compositional characteristics, applicants' claims recite 0.4 to 4.0 % by volume of carbides having an average

particle diameter of 0.2 to 5 μm and 2 to 15% by volume of cementite having an average particle diameter of 0.1 to 1.5 μm are dispersed in a parent phase of the high-toughness martensite containing 0.3 to 0.8 wt% C. Nitrides over 0.4 % by volume are not contained.

Obviousness Rejection

Claims 1 to 12, 20 to 23 and 25 to 27 were rejected under 35 USC 103 as being unpatentable over EP 950 723 for the reasons set forth in item no. 5 at the top of page 3 of the December 18, 2007 Office Action.

It was admitted in the previous Office Action of June 19, 2007 that a Cr concentration of 2.5 to 10 wt% in the cementite ((FeCr)₃C), as recited in claim 1, is not taught by the prior art.

It was admitted in the December 18, 2007 Office Action that the prior art does not teach prior austenite grains having an ASTM grain size No. 10 as recited in applicants' claim 3.

It was further admitted in the December 18, 2007 Office Action that EP 950723 does not teach induction heating and heating at 150°C/sec or more, as recited in applicants' claims.

It was also admitted in the December 18, 2007 Office Action that EP 950723 does not teach a soluble carbon concentration of 0.3 to 8 wt% in the martensite of the quench hardened layer as recited in applicants' claims.

EP 950 723

A rolling element of EP 950 723 is obtained in such a way that a fine carbide and/or carbonitride having an average grain size of 0.3 μm or less is dispersed in the contact surface structure by carburizing and nitriding. After a cementite of 3 μm or less is dispersed in the surface structure while heating in a temperature region from the A1 temperature to 900°C, a quenching treatment is performed on the rolling element.

Under the heat conditions for dispersing the cementite, since heating is performed in a carbon concentration range where austenite and cementite coexist, it is clear that the carbon concentration in a martensite after quenching does not exceed the

eutectoid carbon concentration of the alloy system (i.e., 0.8 wt% C).

Further, it is clear that because of the nitriding treatment, 0.4 to 2.5 wt% of nitrogen is diffused in the contract surface structure of the rolling element.

Withdrawal of the 35 USC 103 rejection is thus respectfully requested.

Information Disclosure Statement

An INFORMATION DISCLOSURE STATEMENT is being filed concomitantly herewith.


Submitted concomitantly herewith is an English-language abstract of JP 48-23617 (which was cited in the INFORMATION DISCLOSURE STATEMENT dated October 16, 2007).

If the Examiner has any comments, questions, objections or recommendations, the Examiner is invited to telephone the

undersigned at the telephone number given below for prompt
action.

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Respectfully submitted,

A handwritten signature in black ink, appearing to read "Richard Barth", written over a horizontal line.

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Enclosures: (1) PETITION FOR EXTENSION OF TIME
(2) INFORMATION DISCLOSURE STATEMENT
(3) English-language translation of
JP 48-23617

Request for Patent

July 30, 1971

Commissioner of Patent Office Takehisa Doi

1. Title of the Invention

5 Method for Producing High Strength Steel With High
Hardness

2. Inventors

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5. Items of documents enclosed

- 20 (1) Specification 1
 (2) Drawing 1
 (3) Power of attorney 1
 (4) Copy of application form 1

(19) Japan Patent Office (JP)

25 Publication of Patent Application

(21) Application Number 47-46424

(11) Publication Number 48-23617

(43) Date of Publication of Application: March 27, 1973

Request for Examination: Filed (3 pages in total)

30 Request for Examination: Filed

Intraoffice Reference Number

6327-42

6659-42

(52) Domestic Classification

35 10 J183

10 J172

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SPECIFICATION

1.TITLE OF THE INVENTION

Method for Producing High Strength Steel With High Hardness

2.CLAIMS

15 1. A method for producing a high strength steel with high
hardness comprising the steps of rapidly heating steel
comprising 0.50 to 1.40% of C, 1.3% or less of Si, 1.3% or less
of Mn, 0.4 to 2.0% of Ni, 0.30% or less of Mo, and 1.0% or less
of Cr at a rate of 15°C/min or less up to 800 to 850°C directly
20 above an A_{c1} or A_{c3} transformation temperature, quenching the
steel within 15 minutes after the steel reaches a quenching
temperature, and tempering the steel at a temperature of about
200°C or lower.

3.DETAILED DESCRIPTION OF THE INVENTION

25 The present invention primarily relates to a method for
producing a high strength steel with high hardness used for
wear-resistant members of large equipment such as construction
machines and industrial machines.

Though a conventional hardened steel, for example a
30 carbon tool steel, can yield very high hardness since it
contains as much as 0.8 to 1.5% of carbon, it has a disadvantage
of lacking toughness. Therefore, it is suitable for using as
wear-resistant members of a large machine in sections where
particularly high stress is not exerted, but in sections where
35 high stress is exerted, since members having high toughness have

to be used even at the expense of wear resistance, there was inconvenience that this kind of members generally wear early and have to be often replaced.

5 The present invention was made in view of the above state of the art, and it is an object of the present invention to provide a method for producing a high strength steel with high hardness which enhances the toughness of a hardened steel with high without reducing hardness to improve the above-mentioned defects of conventional hardened steels.

10 Hereinafter, the method for producing the high strength steel with high hardness, which is an example of the present invention, will be described in detail. Steel comprising 0.50 to 1.4% of carbon (C), 1.3% or less of silicon (Si), 1.3% or less of manganese (Mn), 0.4 to 2.0% of nickel (Ni), 0.30% or
15 less of molybdenum (Mo) and 1.0% or less of chromium (Cr) (hereinafter, denoted by an atomic symbol) is normalized once by the same method as conventional one, and then the steel is rapidly heated at a rate of about 15°C/min or more up to 800 to 850°C directly above an A_{c1} or A_{c3} transformation temperature
20 to prevent the dissolution of carbide in austenite from adequately proceeding, and the steel is quenched within 15 minutes after the steel reaches a quenching temperature. Next, the steel is tempered at a temperature of 200°C or lower, for example about 130°C, after quenching and thereby the high
25 strength steel with high hardness is obtained. The strength was compared between the obtained high strength steel with high hardness and a conventional carbon tool steel, for example, SK 3, to obtain the results shown in Fig. 1. That is, in the present invention, by adding Ni in the steel containing a large amount
30 of carbon, rapidly heating and quenching the steel by a means such as high frequency induction heating or the like, the dissolution of carbide in austenite is controlled to reduce an amount of carbon in martensite, and consequently a hardened structure consists of low carbon martensite and residual
35 carbide, high hardness can be attained by enhanced dispersion

of the residual carbide and less residual austenite, and toughness is improved by low carbon martensite containing Ni.

Relationships between hardness and strength, deflection, absorbed energy are compared between the hardened steel in which
5 toughness is enhanced by the above-mentioned addition of a large amount of Ni and special quenching and the conventional hardened steel to obtain Fig. 2. As is apparent from this Figure, it is clear that if having the same hardness as the conventional hardened steel, the hardened steel of the present invention is
10 extremely superior in all of a breaking load, a deflection, and absorbed energy and the toughness is enhanced. In addition, the conventional hardened steel contains little Ni or does not contain Ni at all and has a small quenching rate, and symbols in Figures represent the difference between carbon contents and
15 solidly shaded symbols represent conventional hardened steels. As described above, the present invention is characterized by rapidly heating steel comprising 0.50 to 1.40% of C, 1.3% or less of Si, 1.3% or less of Mn, 0.4 to 2.0% of Ni, 0.30% or less of Mo, and 1.0% or less of Cr by a means such as high frequency
20 induction heating or the like, and then tempering the steel at a temperature of about 200°C or lower, and by adding Ni to a high carbon steel and rapidly quenching the steel, the dissolution of carbide in austenite is controlled and thereby an amount of carbon in martensite is reduce, and consequently
25 a high strength steel with high hardness consisting of low carbon martensite and residual carbide can be attained, and toughness is significantly improved by low carbon martensite while maintaining the hardness of the high carbon steel by enhanced dispersion of carbide and less residual austenite, and
30 the present invention exerts excellent effects particularly when it is used in wear-resistant members to which excessive stress is.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Drawings represent an example of the present invention,

Fig. 1 is a bar chart showing a comparison of the strength of the present invention and a conventional hardened steel, and Figs. 2 are diagrams showing relationships between hardness and strength, deflection, absorbed energy.

5 Fig. 1

- ① Breaking Load (kg)
- ② Deflection (mm)
- ③ Absorbed Energy (kg·m)

Fig. 2

- 10 ① Breaking Load (kg)
- ② Deflection (mm)
- ③ Absorbed Energy (kg·m)
- ④ Conventional
- ⑤ Present Invention

15

Amendment (Voluntary)

August 14, 1972

Commissioner of the Patent Office: Takehisa INOUE

1. Indication of the Case

5 Application Number 46-56709

2. Title of the Invention

Method for Producing High Strength Steel With High Hardness

3. Person Amending a Description: Komatsu Ltd.

Relation to the Case: Applicant for Patent

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5. Date of Order for Amendment: Voluntary Amendment

6. Contents of Amendment

15 See the separate sheet attached herewith.

(1) Description of 2. CLAIMS in the present specification
attached is amended as follows.

A method for producing a high strength steel with high
hardness comprising the steps of rapidly heating steel
20 comprising 0.50 to 1.40% of C, 1.3% or less of Si, 1.3% or less
of Mn, 0.40 to 2.0% of Ni, 0.30% or less of Mo, and 1.0% or less
of Cr at a rate of 15°C/min or more directly above an A_{c1} or
 A_{c3} transformation temperature, quenching the steel within 15
minutes after the steel reaches a quenching temperature, and
25 tempering the steel at a temperature of about 200°C or lower.